Executive Function: Generational and Environmental Influences

Research Thesis

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by

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Abstract

Executive function (EF) is one of the most important cognitive processes, and EF dysfunction can contribute to an array of negative outcomes. There is evidence that the preschool years are a time of rapid development in EF; additionally, there is evidence that factors such as maternal EF, depression, parenting styles, and SES can influence the development of EF during a child's life. The current study hypothesized that maternal EF, SES, and maternal depression will all act negatively on the development of a child's EF, and also that maternal depression will negatively influence maternal EF. Participants included 90 mother-child dyads from the Columbus area. All of the children recruited were between 3 and 3½ years old. EF was assessed in laboratory setting, with the Wisconsin Card Sort Test (WCST) being used to measure maternal EF. Child EF was assessed on two dimensions; attentional flexibility and inhibitory control. Attentional flexibility was assessed using the Dimensional Change Card Sort Test (DCCS), and inhibitory control with the Bear and Dragon, Shapes, and Day and Night tasks. Maternal depression was assessed using the *Center for Epidemiologic Studies Depression Scale* (CESD), and family income was used as a proxy for SES. Multiple regression analysis revealed a connection between maternal depression and maternal perseverative errors on child EF performance, as well as a moderate correlation between maternal depression and maternal EF. However, no relationship was found between SES and child EF. The results of this study add to the understanding of the generational and environmental influences on a child's EF development during the pre-school years; understanding which can be useful in preventing the negative outcomes associated with EF deficits.

Executive Function: Generational and Environmental Influences

Executive function (EF) has been broadly defined as an umbrella term for cognitive processes which are used to achieve a specific goal (Elliot, 2003). Deficits in these cognitive processes have been shown to be related to a battery of poor outcomes; the psychosomatic (Watkins & Brown, 2002; Robinson, Thompson, Gallagher, Goswami, Young et al., 2006), social (Barkley 2011), and economic (Moffitt, Arsenault, Belsky, Dickson, Hancox, Harrington, Houts, Poulton, Roberts, Ross, Sears, Thomson, & Caspi., 2011) outcomes of EF dysfunction can be devastating. Individual differences in childhood EF are also shown to be of importance; EF is predictive of emotional-based eating in preschool children (Pieper & Laugero, 2013), obesity in children and adolescents (Reinert, Poe, & Barkin, 2013), and EF's powerful association with the incidence of attention deficit hyperactivity disorder (ADHD) and autism spectrum disorder (ASD) is well documented in literature (Pennington & Ozonoff, 1996; Barkley 2011; Gilotty, Kenworthy, Sirian, Black, & Wagner, 2002). In addition to ADHD and ASD, EF has been shown to influence a host of other psychosomatic and neurological disorders, such as depression (Watkins & Brown, 2002), bipolar disorder (Robinson et al., 2006), and Parkinson's disease (Wobrock, Ecker, Scherk, Schneider-Axman, Falkai, & Gruber, 2009).

It is clear that EF is a crucial element influencing the outcome of a person's life, both in childhood and beyond. Given its involvement in a variety of negative social, economic, neurological, physical, and psychological outcomes, furthering the understanding of EF and its development is crucial. Early childhood is a time of extreme importance for the development of EF (Anderson & Reidey, 2012), yet relatively little research has been conducted on the influences of genetic, familial, and generational factors on the early development of this critical cognitive process.

Executive Functioning and Its Development

Research has shown that the EF develops rapidly during the preschool years (Anderson & Reidey, 2012) as a result of expeditious neural development, especially in the prefrontal cortex (Zelazo & Carlson, 2012). Also, while EF in adults is a diverse set of many processes, recent research has pointed to EF in childhood being a more unitary concept, with most EF at this stage being focused in a self-directive mode, consisting of inhibitory control and working memory (Weibe, Sheffield, Nelson, Clark, Chevalier, & Espy, 2011). One recent model, the Extended Phenotype Model of EF (Barkley, 2013), has these two categories of EF as components of the Instrumental-Self-Directed Level of EF, a relatively low level of EF which is focused inward on the individual. This mode is used primarily to control behavior and impulses to achieve future goals. Research has suggested that this level of EF provides the foundation for the other, more advanced, levels of EF which serve to develop one's ability to interact with the world around them (McCabe, Rodiger, McDaniel, Balota, & Hambrick, 2010), and as such, deficits in this level of EF can hinder further development into these advanced levels later in life.

Given that EF develops quickly during the preschool years, and that during this period EF is heavily set into the critical instrumental-self-direct level, it becomes clear how various influences on the development of EF in early childhood could have sweeping effects throughout the child's life.

Genetic and Generational Influences on Executive Function Development

It has been suggested that individual differences in EF are almost entirely genetic (Friedman, Miyake, Young, DeFries, Corley, Hewitt, 2007). There is research indicating that the EF of parents genetically influences functioning in EF in their children (Jester, Nigg, Puttler, Long, Fitzgerald, & Zucker, 2009). Though the current study did not evaluate the influence of genetics on EF, better probing the predictive relationship between a mother's EF and her child's could potentially lead to earlier monitoring and identification of EF dysfunction in children. Earlier identification of this EF dysfunction may result in earlier intervention for this dysfunction, and as a result, fewer negative outcomes for children at-risk for EF deficit.

Familial and Environmental Influences on Executive Function Development

While genetics play a powerful role in one's level of EF, the effect of the environment on a child's development of EF cannot be completely discarded. Research has provided evidence that children raised in a punitive environment performed significantly worse on tests assessing EF than did children in a non-punitive environment (Talwar & Carlson, 2011). Similarly, parental scaffolding at a young age was shown to have a positive relationship on the development of EF in children (Hammond, Müller, Carpendale, Bibok, & Libermann-Finestone, 2011). Outside of how a supportive or punishing environment can affect childhood EF, there is also evidence showing the influences of demographic and familial factors on the development of child EF (Rhoades, Greenberg, Lanza, Blair, 2010). Inquiry into how environmental factors influence child EF could yield a deeper understanding of how to enhance child EF, and could potentially lead to the development of different interventions designed to improve the EF of children.

Effects of Maternal Depression on Child EF. Maternal depression has been shown to have wide range of negative effects on child development. There is research to suggest that depression in mothers is associated with long-term impairment of mother-child bonding (Moehler, Brunner, Weibel, Reck, & Resch, 2006), this depression has also been shown to contribute to more negative parenting behaviors in the mother as well as disengagement in her child (Lovejoy, Graczyk, O'Hare, Neuman 2000). These effects on child-parent behavior and attachment as mediated by maternal depression can negatively influence a large portion of a developing child's family environment.

Maternal depression has also been linked with cognitive impairment, including the development of a child's EF. There is evidence to show that children raised by depressed mothers perform more poorly on tests of cognitive assessment than their peers (Cogill, Caplan, Alexandra, Robson, & Kumar, 1986). Maternal depression has also been shown to produce an effect on the development of a child's EF as a result of poor interactions between mother and child during early infancy (Rhoades et al., 2010). However, it is important to note that most data highlighting the negative cognitive and EF ramifications of maternal depression focused primarily on children younger than pre-school age, a critical time for EF development. The current study hopes to build off of the findings of these earlier studies, and illuminate how the environmental effects of maternal depression can influence the executive function of children in the crucial pre-school age range.

Effects of Socio-Economic Status on EF. Socioeconomic status (SES) can be defined as an individual's, or group's, level of economic and social position in regards to others. A variety of factors can influence SES, such as race (Williams, Yu, Jackson, & Anderson, 1997), and educational level (Palardy, 2008). Household income is a major component of one's SES, and has been shown to be a useful measure of the construct (Duncan, Daly, McDonough, & Williams, 2002).

SES has been shown to significantly influence child's family environment. It has been found that families of low SES are more likely to experience divorce (Jalovaara, 2003). Additionally, SES has also been shown to affect the parenting styles of families, as parents of children in low SES families are generally less likely to foster self-determination behavior in their children (Zhang, 2005). These effects that SES produces on a child's familial environment, such as parental marital status and parenting style, have the potential to alter multiple aspects of a child's development, such as development of their EF.

Research has provided some evidence for this association of SES and child EF; children in families of low SES tend to perform worse on measures of three aspects of EF: inhibition control, working memory, and attention flexibility (Sarsour, Sheridian, Jutte, Nuru-Jeter, Hinshaw, & Boyce, 2011). Again, much of the research into the relationship between development of child EF and household SES is limited to age ranges outside of the pre-school years. Given the effects that SES has been shown to have on familial environment and child EF, further understanding of the influence of SES on development of EF during the important pre-school years is warranted.

The Current Study

The current study was aimed at furthering the understanding of familial and generational influences on the development of EF in preschool-aged children. More specifically, this study aimed to examine the association between maternal EF and depressive symptoms, the relationship of familial environment on the development of child EF, as well as the generational influence of maternal EF on the level of her child's EF. Better understanding how these various generational and environmental factors work to influence the development of EF in children could yield immense benefits in regards to earlier intervention in children at risk for EF defecit, as a well as a better grasp of the various mechanisms which influence the development of this crucial behavioral construct.

Hypotheses

The current study aimed to replicate the finding that those mothers who exhibit deficits in EF would be more likely to have elevated depressive symptoms. It is also hypothesized that mothers who exhibit more depressive symptoms would be more likely to have children who possess lower EF. Children raised in homes of lower SES will display lower EF than those raised in higher SES homes, and that mothers who possess lower EF themselves will be more likely to have children who also possess stunted levels of EF.

Method

Participants

The participants in the study were 90 mother-child dyads recruited from the Columbus, OH area. Participants were recruited through a variety of methods including phone recruitment, posting of flyers at mental health centers and daycares, and through email. Participants of the study were mothers who were 21 years or older, who had a child between the ages of 3 and 3½, and who did not have a history of any psychiatric disorders other than depression. Children with developmental delay were not included in the study.

Mothers. The mothers of the study represented a wide range of backgrounds. The average age of a participant was 30.2 years old (*SD* = 5.08). Mothers were typically well educated, with 54.2% of the sample holding a bachelor's degree or above. A little over half

(56.7%) of the households had an annual income near or slightly over the Ohio average of $48,246. The participants of the study represented a sizeable range of incomes, with 22.2% of households making less than $20,000 annually and 13.3% of households making over $90,000 annually. Thirty-one of the mothers (34.4%) were above the clinical cutoff for depression on the Center for Epidemiologic Studies Depression Scale (CESD) (Radloff, 1977).

Children. Children's age ranged from 3.01 to 3.66 years, with a mean of 3.23 years old (*SD* = 0.18). The ratio of sexes in the participant pool skewed slightly female with 50 children (55.6%) being female and 40 children (44.6%) being male.

Measures

Child assessments

Child EF was assessed based on two dimensions: inhibitory control and attention shifting. Inhibitory control was assessed using the Bear and Dragon Task (Murray & Kochanska, 2002), the Shape Task (Murray & Kochanska, 2002), and the Day and Night task (Kochanska, 2007). Attention flexibility was assessed using the Dimensional Change Card Sort Task (DCCS; Zelazo et al., 2003). These tasks were assessed in a laboratory setting at a singular time point, with children coming in with their mothers for a roughly two hour long study visit.

Bear and Dragon Task. The Bear and Dragon task assessed inhibitory control via a game involving two puppets: a bear puppet and a dragon puppet. During the game, the experimenter put the two puppets on either side of her hands. She then instructed the child to listen to what the bear puppet tells him/her to do, and to ignore what the dragon puppet tells him/her to do.

Before starting the task, the experimenter introduced the rules of the game, and performed at least two practice trials, or as many practice trials as it took for the child to understand the rules of the game. The task then consisted of a two blocks of six trials, for a total of twelve trials. After six trials, the child would be reminded of the rules of the game, and then the task would begin again. Bear commands and dragon commands occurred with enough frequency to produce an equal number of trials of both kinds of request.

The child was awarded 2 points for performing what the bear asks of him/her, 1 point for a partial or incorrect movement, such as touching his ears when told to stick out his/her tongue, and 0 points for ignoring the bear. The dragon trials were scored opposite of the bear trials; 2 points were awarded for ignoring the dragon, 1 for a partial or incomplete movement, and 0 for performing the requested command. Thus, the higher a child scored on the Dragon task, the better their inhibitory control, and vice-versa.

Shape Task. The Shape Task assessed inhibition using a set of pictures that the child was asked to identify. During the task, the child was shown a variety of small images contained within the outline of a larger image.

The experiment began with a short explanation of the game to the child. The experimenter first showed them a photo containing each possible type of image encountered during the Shapes Task, making sure that the child knew what each picture is. The experimenter then showed the child a test card, and made sure the child understood the rules of the game, that is, that they were able to name the little shapes contained within the images of the big shapes. Once it was established that the child understood the rules, the task began.

During each trial of the shape task, the child was first primed with a solid, colored image of the large shape. They were then shown an image of the outline of this large shape filled with smaller shapes inside of it. The experimenter asks the child to tell her what the little shapes in the picture are. The task was run for a total of 24 trials, and the child is reminded of the rules of the game for the first two trials.

The child was awarded 0 points for an incorrect answer, 1 point for a self-corrected response, and 2 points for a correct response. The higher their score on this task, the better their ability to inhibit their proponent impulses.

Day and Night Task. During the Day and Night Task, the child was to play a game where he/she is presented with a picture of day sky (with the sun on it) and a picture of night sky (with the moon and stars on it). They were then told to point to the night sky when the experimenter said “Day” and point to the day sky when the experimenter said “Night.”

The task began with the child being presented the two cards before being asked to indicate to the experimenter which card was the day sky (sun) and which card was the night sky (moon). Once the child correctly identified the cards, the experimenter would explain to them the rules of the day and night game. Practice trials were run until the child understood the rules of the game. The task was then run for ten trails. After five, the child would take a break, and the rules would then be re-explained to them. The task would then proceed for another five trails. A higher score on the Day and Night Task indicates a higher ability to inhibit responses.

DCCS. The DCCS is a card-sort game played in three phases; a demonstration phase with two trials, a pre-switch phase with six trials, and a post-switch phase with six trials. The child was first presented with two cards, one containing a blue rabbit and the other a red boat, and two trays for them to sort the cards into. The experimenter then explained the rule which separated the target cards; the cards could be separated by shape (rabbit and boat), or color (red or blue). One of these rules was randomly chosen to be the sorting rule for the pre-switch phase.

During the demonstration phase of the task, the experimenter used the blue rabbit and red boat cards for demonstration, and made sure that the child understood the rules of the game. Once it was clear that the child comprehended the task, the pre-switch phase began.

During the pre-switch phase, the child was presented with two bivalent test cards: either red rabbits or blue boats. The child was then asked to sort these cards based on the chosen pre-switch dimension, color or shape. The rules of the game were repeated every trial for the child, but no feedback on their performance is given. After six trials of the pre-switch phase, the child was told to play a different game, and sort by the dimension not chosen as the pre-switch sorting rule. The post-switch phase ran for six trails, and like the pre-switch phase, the child is reminded of the rules before every trial, presented with the card, and sorts the card into one of the two trays based on the rules of the game. The sorting result of each trial and the total number of correct pre- and post-switch trials are recorded.

Children are awarded one point for correctly sorting the cards based on the current sorting rule, and they are awarded zero points for an incorrect sort.

Maternal assessments.

Maternal EF. Maternal EF was assessed using the Wisconsin Card Sorting Task (WCST; Heaton et al., 1993). In the WCST, the participant was asked to sort cards based on one of three dimensions; shape, color, or number of images on the card. Which dimension the participant is to sort by is not told to the participant; they merely sort cards until they begin to get notifications that their sorts are incorrect.

During the lab visit, the mothers were taken to a room separate from their child and had the WCST administered to them via a computer program. Minimal instructions were given to reduce the extent to which the participants understood how the WCST worked. Once the program was set-up and the minimal explanation was given, the mother was left alone to complete the task.

During the WCST, the mother was shown one target card, and asked to sort it based on one of three dimensions; color, shape, or number. The participant was provided with negative feedback, in the form of a large “WRONG” being displayed on the screen, for each incorrect sort, and was provided with positive feedback, in the form of a large “CORRECT” being displayed on the screen for each correct sort. Once the participant completed ten correct trials of the WCST in a row, the desired dimension of sorting was switched without warning to the participant. The participant then experimented with different sorting dimensions before finding one which is once again correct. The WCST ran for a total of 64 trials.

A participant commits a perseverative error when they perseverate to a previous rule-set, and sort the cards by a previous and incorrect dimension, despite receiving negative feedback. The performance of participants on this task was assessed using the number of perseverative errors made during the task. The more of these perseverative errors made by a mother on the WCST, the lower their assessment of EF.

Family Environment Assessments

These assessments were made using an on-line questionnaire that the mother completed at home before attending the lab visit.

Maternal Depressive symptoms. Maternal depressive symptoms were assessed using the CES-D, a self-completed questionnaire where the mother is presented 20 statements about aspects of her life, and was asked to answer how frequently these statements were true. Typical statements include "My appetite was poor", "I could not shake off the blues", and "I had trouble keeping my mind on what I was doing." For each of these statements, the mother answered with one of the following options: (0) Not at all or less than 1 day last week, (1) one or two days last week, (2) three to four days last week, (3) five to seven days last week, (4) nearly every day for two weeks. The threshold for clinically significant depression symptoms is 16 points on the CESD. The higher one scores on the CESD, the more severe the symptoms. The criterion validity of the CESD is well documented by previous studies (Beekman, Deeq, Van Limbeek, Braam, De Vries, & Van Tilburg, 1997; Haringsma, Engles, Beekman, & Spinhoven, 2004), and in the current study, it showed high internal consistency (Cohen's $\alpha = .94$).

SES. Household income was used as a proxy of family socio-economic status. Mothers completed a demographic questionnaire, in which the question "what is your annual household income" was asked. The participant answered one of twelve options: 1=Less than $10,000, 2=$10,000 to $20,000, 3=$20,000-$30,000, 4=$30,000-$39,999, 5=$40,000-$49,999, 6=$50,000-$59,999, 7=$60,000-$69,999, 8=$70,000-$79,999, 9=$80,000-$89,999, 10=$90,000-$99,999, 11=$100,000-$149,999, 12=$150,000 or more.

Results

Preliminary Analysis

Descriptive statistics are presented in Table 1. All of the generational and environmental variables of interest had a relationship with child's performance on at least one of the inhibitory control tasks. Household income was found to have a small correlation with child performance on the Shapes Task (r = .21, p < .05); a similar correlation was also found between maternal perseverative errors and performance on the Shapes Task (r = -.22, p < .05). In addition to this, maternal EF also displayed a moderate correlation with child performance on the Bear and Dragon Task (r = -.33, p < .01). There was also an association between maternal depression and maternal perseverative errors (r= .24), as well as between a mother's level of education and maternal perseverative errors (r = -.28, p < .01). Performance on the Shapes Task displayed a moderate correlation with performance on the Day and Night Task (r = .39, p < .02), though this relationship was not found between any of the other inhibitory control tasks. There were no significant correlations between performance on DCCS and any of the other variables in the study.

Table 1: ***Means, Standard Deviations, and Bivariate Correlations of Variables in the Study***

			Correlation							
Variable	*M*	*SD*	1	2	3	4	5	6	7	8
1. Child Age	3.23	.18	----	-.10	.17	.15	.26	.07	.12	.03
2. Household Income	5.53	3.29	----	----	**-.46****	-.10	**.21***	-.08	-.02	.14
3. Maternal Depressive Symptoms	13.5	12.0	----	----	----	**.24***	-.15	-.20	-.03	.03
4. Perseverative Errors	8.34	5.21	----	----	----	----	**-.22***	-.08	**-.33****	.10
5. Shapes Task	13.0	8.25	----	----	----	----	----	**.39****	.22	.10
6. Day and Night Task	18.3	7.09	----	----	----	----	----	----	.16	.21
7. Bear and Dragon Task	6.63	5.86	----	----	----	----	----	----	----	.01
8. DCCS	4.68	2.03	----	----	----	----	----	----	----	----

Note: *p<0.05. **p<0.01. Household income and education are categorical variables: Household income (1=Less than $10,000, 2=$10,000 to $20,000, 3=$20,000-$30,000, 4=$30,000-$39,999, 5=$40,000-$49,999, 6=$50,000-$59,999, 7=$60,000-$69,999, 8=$70,000-$79,999, 9=$80,000-$89,999, 10=$90,000-$99,999, 11=$100,000-$149,999, 12=$150,000 or more)

Analysis of Findings

Multiple regression analysis was performed to assess the influence of the generational and environmental variables of interest on child EF. Outside of SES, all of the environmental and generational variables displayed an association with performance on assessments of inhibitory control in children. Analysis found no significant relationship between the attentional flexibility (DCCS) assessment and the independent variables. Child's age was shown to have a significant relationship with a child's performance on the Shapes Task ($\beta = .32$, $p < .01$). A summary of the analysis can be found in Table 2. This analysis does not examine the relationship between maternal depression and maternal EF; instead, the connection between these two variables was assessed using a correlation analysis.

Maternal EF and maternal depressive symptoms. The current study aimed to replicate the finding that mother who display deficits in EF would be more likely to display more symptoms of depression. Models revealed a moderately significant correlation between a mother's score on the CESD and her number of perseverative errors ($r = .24$, $p < .05$).

Maternal depressive symptoms and child EF. It was hypothesized that children of mothers with elevated depressive symptoms would display lower levels of EF. Consistent with the hypotheses, a significant relationship between a mother's depressive symptoms and her child's inhibitory control assessed in the Day and Night task was found ($\beta = -.20$, $p < .05$). However, there was no significant relationship found between maternal depressive symptoms and child inhibitory control in the Shapes Task ($\beta = -0.42$, $p = .59$) and Dragon task ($\beta = -.01$, $p = .93$), and attentional flexibility in the DCCS ($\beta = .06$, $p = .64$).

Maternal EF and child EF. The hypothesis that mother's level of EF would be predictive of her child's level of EF was tested in the regression model. There was found to be a moderately significant relationship between the number of mother perseverative errors and her child's inhibitory control in the Dragon Task (β = -.33, p < .01), as well as a small significant relationship with child's inhibitory control assessed in the Shapes Task (β = - .23, p < .05). While both of these findings are in-line with hypothesized outcomes, this significant association was not found between maternal perseverative errors and her child's performance on the Day and Night task (β = - .06, p = .61), nor her perseverative errors and her child's performance on the DCCS (β = .10, p = .39).

SES and child EF. It was hypothesized that the lower a household's level of SES, the lower a child's level of EF. While a significant correlation was found between SES and child inhibitory control as assessed on the Shapes Task, this relationship was not replicated through the regression analysis (β = .19, p = .09). Furthermore, SES showed no significant relationship with any of the other target variables.

Table 2: ***Results of Multiple Regression Analysis on Child EF Level***

	DCCS				Bear and Dragon Task				Shapes Task				Day and Night Task			
	B	*SE B*	β	t	*B*	*SE B*	β	t	*B*	*SE B*	β	t	*B*	*SE B*	β	t
Child Age	.35	1.3	.03	.27	4.07	4.65	.14	1.15	15.0	4.67	.32	**3.20****	4.07	4.65	.11	.88
Household Income	.11	.08	.19	1.51	-.45	.29	.06	-.432	.47	.28	.19	1.71	-.45	.29	-.21	-1.6
Mother Depression	.01	.02	.06	.47	-.19	.08	-.01	-.089	-.04	.08	-.06	-.54	-.19	.08	-.30	**-2.25***
Maternal EF Errors	.04	.04	.10	.87	-.09	.17	-.35	**-2.92****	-.37	.16	-.23	**-2.26***	-.09	.17	-.06	-.51
ΔR^2				.04				.13				.19				.09
ΔF				.79				2.48				4.71				1.65
df				4, 83				4, 66				4, 83				4, 67

Note: *p<0.05. **p<0.01. Maternal EF errors=Mother perseverative errors on the WCST. . Household income has 12 levels (1=Less than $10,000, 2=$10,000 to $20,000, 3=$20,000-$30,000, 4=$30,000-$39,999, 5=$40,000-$49,999, 6=$50,000-$59,999, 7=$60,000-$69,999, 8=$70,000-$79,999, 9=$80,000-$89,999, 10=$90,000-$99,999, 11=$100,000-$149,999, 12=$150,000 or more)

Discussion

The current study found significant generational and environmental influences on the development of child EF during the pre-school years. Maternal depression was shown to have a negative effect on the development of child inhibitory control; similarly, mothers with lower EF tended to also have children display low levels of inhibitory control. These findings support the initial hypotheses of the study, and are consistent with research regarding children at other ages, and offer specificity to the study of the various aspects influencing development of child EF during preschool.

Also consistent with previous research was the relationship between maternal EF and maternal depressive symptoms, where mothers with more depressive symptoms tended to have lower levels of EF (Cogill et al., 1986; Rhoades et al., 2010). This relationship between EF and depression adds upon previous findings regarding the subject, further cementing the association between EF and depression. This connection provides further evidence for the negative outcomes of EF, as well as a way of possibly identifying mothers who display executive dysfunction.

In regards to the generational influences on EF, findings that mothers with lower levels of EF functioning also tended to have children with lower levels supports the initial hypothesis that mother EF would be predictive of her child's. This finding is in line with previous research documenting this relationship (Jester et al., 2009), and provides additional illumination as to the extent of this influence in preschool aged children. These findings provide a possible route for early identification of child EF dysfunction; by better understanding this predictive generational relationship in EF between mothers and their children, children at-risk for executive dysfunction can be identified earlier, resulting in earlier intervention and better outcomes.

There are several steps which can be taken to limit the effects of executive dysfunction on children. There is growing research showing that the implementation of activities, such as special computer games, martial arts, and specific class curriculums can improve the EF of children during preschool (Diamond, Barnett, Munro, 2007). By identifying children who are at-risk for EF deficits earlier, earlier measures to improve EF functioning can be taken. The findings of this study work to enhance this early-identification ability through an increased understanding of the generational predictive associations of child EF.

The study finding that children of depressed mothers tended to do worse on measures of EF was also in-line with initial hypotheses. The negative association found between the environmental factor of maternal depression and her child's EF development is in line with previous research on the influence of maternal factors on child EF (Cogill et al., 1986; Rhoades et al., 2010). This finding adds to the understanding of the influences that act on a child's EF development around the pre-school ages. With this understanding comes an increased capability to identify environments which are potentially damaging to the development of child EF, allowing the implementation of measures which can limit the damage posed by the environment on child EF.

The environment around a child can be changed to help improve their EF functioning. Children with low EF can be placed in environments promoting enhanced self-regulation with tools like a "wrist-list", a list attached to a child's wrist to help them keep track of what they need to do throughout the day. There is evidence that a wrist-list, and similar environmental tools which can be used to help a child self-regulate, can limit the effects of low EF (Yeager & Yeager, 2013). The results of the current study regarding familial environment add to previous research on familial environment, and could potentially be used to identify other environmental factors which can be used to aid children with executive dysfunction.

However, not all of the variables of interest displayed a connection with child EF. While SES displayed a correlation with child inhibitory control, this association was lost when analyzed in multiple regression, implying that the effect of SES are accounted for by other independent variables. This finding does not support the initial hypothesis that low SES households will produce children with lower levels of EF functioning. It is also out of line with some previous research (e.g., Sarsour et al., 2011), which suggested that a child's SES environment does not influence the development of EF. These findings add to the data regarding this possible association, and show that it is an area which deserves additional inquiry. Additionally, no associations were found between child attentional control and any of the independent variables.

Limitations of the Current Study

Children's performance on DCCS suggested a ceiling effect, with a high mean score (4.68). It is possible that the DCCS was too easy for many children in this sample, and therefore failed to capture individual variations in the true levels of attention flexibility.

There were also few significant correlations among inhibitory control measures with the exception of the moderate association between the Day and Night Task and the Shapes task. There is evidence that differences observed between individual measures of EF constructs, such as inhibitory control, can result as a result of the difficult of the task relative to the age group, with some tasks being harder for three-year olds than others .This effect influences different measures in different ways; for example, the Bear and Dragon task becomes much easier as a child ages, while the Day and Night task shows little appreciable change in difficulty for older children (Carlson, 2005). Given the six month age range of children in the study, it is possible that children at different ages performed better on certain tasks than the young children in the sample, while performing equal to them on others, limiting the inter-test reliability of the inhibitory control measures. This age effect was seen in study results with the tendency for older children to outperform their younger peers on the Shapes Task, an effect not seen in the Day and Night, or Bear and Dragon assessments. However, the findings of the current study regarding the relationship between these various inhibitory control measures warrant further analysis.

Additionally, several participants in the study presented with extremely low percentile rankings for their WCST scores; while it is impossible to determine the cause of this trend in the participant pool, participant fatigue/distraction is a plausible explanation.

Future Research

Future research into the study of EF is of extreme importance. The current study provides groundwork for other studies to build off of an elaborate upon; while several associations were found between the generational and environmental factors on the child's level of EF, further analysis of these relationships is warranted.

The current study did not aim to address the genetic component which very likely influences the generational effects seen in the data. An inquiry into what extent genetics mediates the generational effects observed in this study is warranted. A study structured with the analysis of both parents could also work to provide more specific generational data, working to further understanding as to which parent, if any, has more of an impact on the development of their child's EF. The inclusion of other family variables would also greatly benefit future study into this topic, such as assessing the influence of siblings or extended family on the development of EF, as well as the influence of parenting styles and parent-child interactions. A more broad selection of participants from wider geographic areas could also expand meaningfully upon the findings of the current study.

Future study could also include a more exhaustive list of EF components assessed, in both the mother and the child. Though inhibitory control is an important component of EF during the preschool years of a child's life, more closely examining other aspects of EF, such as working memory or attention flexibility, could provide a deeper understanding of how different generational and environmental factors could influence the development of EF holistically.

Long-term monitoring of children would supply data on how these variables affect children past the age of 3. A longitudinal study on these generation and environmental influences could furnish understanding as to how the influence of these factors on EF wax or wane during a child's lifetime.

General Conclusions

Understanding the illusive and complicated set of processes that make up EF may yield untold benefits. The current study hoped to clarify a rather opaque area of EF study; how generational and environmental factors influenced the development of child EF during the critical preschool years. Nearly all of the examined factors produced some kind of significant effect on the development of child EF, an encouraging result for the current study. However, there remains room for expansion. By building upon this study and forwarding the understanding of how EF works and functions, it then becomes possible to identify children at risk for EF deficit, and intervene in their lives to produce profoundly better outcomes.

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